National Health Interview Survey Linked Mortality File

Introduction

Record linkage refers to the bringing together, from two or more independent files, records believed to relate to the same "entity", e.g. people or families (Fair and Whitridge 1997 – Record Linkage Techniques: Proceedings of an International Workshop and Exposition). The 2004 NHIS Linked Mortality files links 15 years of records of adult participants (age 18 years and older) of the National Health Interview Survey (NHIS) with death records from the National Death Index (NDI). The NHIS is the principal source of information on the health of the civilian, non-institutionalized population of the United States and has been conducted annually since 1957. For detailed information on the NHIS's contents and methods, refer to the NHIS web page. The NDI is a central computerized data base of all certified deaths in the United States since 1979. For detailed information on the NDI's contents and methods, refer to the National Death Index (NDI).

The 2004 NHIS Linked Mortality files represent the *third* linkage of NHIS records to the NDI and supersedes the previous NHIS-NDI linkages issued in 1997 and 2000. The 2004 NHIS Linked Mortality files are available for each NHIS survey year from 1986 through 2000, with mortality follow-up from the NHIS adult participant's date of interview through December 31, 2002. This new resource allows researchers the opportunity to use the richness of the NHIS questionnaires to examine the association of a variety of health and health care factors with mortality.

Overview

The linking of NHIS and NDI records is conducted entirely by probabilistic matching, meaning that no death certificate verification is undertaken for NHIS records that return NDI record matches. NCHS employed a matching methodology for the 2004 NHIS Linked Mortality files that was very similar, but not identical, to the standard methodology offered by the NDI. Specifically, NCHS developed new weights associated with the specific value of each identifying element on the submission record to create scores for potential matches and implemented more restrictive criteria for including potential matches (see Step 3 below). Also, NCHS conducted a new calibration study to determine the cut-off scores that are used to determine whether a NDI match is considered a true match or a false match (Step 4 below).

This document explains the matching methodology NCHS employed to link NHIS records to death records in the NDI. In this document, you will find detailed information on the following steps involved in the NHIS-NDI match process.

1. Creating NDI submission records from NHIS respondent records
2. Selecting potential matches between NHIS and NDI records
   - Selection based upon 7 different criteria
   - Selection creates a pool of potential matches
3. Scoring and classifying potential matches
   - Scores are based upon weights calculated for the *values* of each of identifying data items
   - Classes are based upon *which* identifying data items match

4. Determining final match status and assigning vital status

Figure 1 depicts the NDI matching process for the NHIS surveys. Users interested in a detailed description of the standard NDI matching methodology should refer to the National Death Index (NDI).

NHIS-NDI record linkage

Only NHIS participants 18 years of age or older at time of interview were eligible for matching with NDI records. A second group of NHIS participants were defined as ineligible for NDI linkage because of insufficient identifying data to create a submission record, resulting in unknown (missing) vital status for these adult NHIS respondents. Since ignoring these ineligibles may lead to biased mortality analysis, NCHS developed new sample weights that are adjusted to account for these non-responses. These weights are available on the 2004 NHIS Linked Mortality files. Users should note the percentage of NHIS respondents 18 years and older who are ineligible due to insufficient data markedly increased in 1997 compared with prior years (see Table 1 and 3 in tabular data). For a description of how the new sample weights were created, please refer to Weighting and Sample Design Issues.

1. Submission Records

NCHS prepared a base submission record for the NDI for each eligible NHIS participant for the years 1986 – 2000[1]. Each NHIS submission record contained up to 12 identifying data items (see below). The NHIS routinely collects all of the 12 data items used by the NDI for matching and has essentially 100 percent complete reporting of these items except for social security number (SSN) and middle initial (see Table 3 in Tabular data). In general, there is no attempt to recontact NHIS participants, but NCHS does update and edit identifying information[2]. Names collected during the NHIS interview such as "John Doe", "Female #1", and "Person" are deleted as non-valid names. Names containing obvious keystroke errors such as "Jo9hn" are corrected.

Data items on the NHIS submission record

1. Social Security Number
2. First name
3. Middle initial
4. Last name (or birth surname)
5. Month of birth
6. Day of birth
7. Year of birth
8. Sex
9. State of birth
10. Race
11. State of residence
12. Marital status

[1] As previously noted, there have been two prior NHIS-NDI linkages. For the 2004 linkage, all eligible NHIS survey participant records were submitted to the NDI, not just those that previously had not matched.

[2] For example, selected NHIS years have been linked to data from the Center for Medicare and Medicaid Services that can result in updated or corrected data for name, SSN, and date of birth.

In addition to the base submission record, the NDI allows multiple alternate submission records for each eligible NHIS participant. In order to increase the chances for selection of the correct death record, NCHS generated alternate submission records, e.g. when identification data was questionable or when the NHIS participant had a multi-part name. For a detailed description of the rules NCHS used to generate alternate NHIS submission records, refer to Appendix A.

Before the NDI processes any submission record, each record is screened to determine if it contains at least one of the following combinations of identifying data elements:

1. Social Security number, sex, full date of birth present
2. Last name, first initial, month of birth, year of birth present
3. Last name, first initial, Social Security number present

Any submission record that did not meet these minimum data requirements is determined to be ineligible for record linkage. The number of NHIS participants who were ineligible because they did not meet the minimum NDI data requirements can be found in Table 1 in Tabular Data (column 5). All accepted NHIS submission records are further edited by the NDI system to provide a consistent format for identifying data elements before employing the NDI record search and retrieval process. For example, the NDI editing process converts text to all upper case and removed suffixes from last names. Also, since spelling variants of names are common, NDI codes last names based on the way a name sounds rather than how it is spelled[3]. For example, records with last names Smith and Smyth receive equivalent NYSIIS codes and both would be selected as a potential match for a NHIS submission with Smith as a last name.

2. Selecting NHIS-NDI potential match records

The NDI system selects death record matches based on a set of established match criteria. The seven criteria listed below are the criteria in use at the time of the 2004 NHIS-NDI match.

1. Social Security Number
2. First and Last Name, exact month of birth, year of birth within 1 year
3. Last name, first initial and middle initial, exact month of birth, year of birth within 1 year
4. First and Last Name, exact month of birth, exact day of birth
5. Last name, first initial and middle initial, exact month of birth, exact day of birth
6. First name, father's surname, exact month of birth, exact year of birth
7. For females only, first name, exact month and year of birth, and last name from the user's record matching birth surname on the NDI record (for females who change their name after marriage, but don't supply a birth surname)

Any NDI record that matches a NHIS submission record on any one of these seven criteria is selected. Since one or more NDI records may be matched to a given NHIS record, the result is that the NDI record selection process can return several hundred matches for each NHIS person. For this reason, the NDI records selected are referred to as a set of *potential* matches since many of the records will be non-matches or duplicate records.

[3] The sound alike system is a variation of the New York State Identification Intelligence System or NYSIIS, which converts a name to a phonetic coding.

3. Scoring and classifying potential match records

Given the multiple number of death records that may be selected for a single NHIS participant, an approach is needed to assess the quality of the potential matches so that poor quality matches can be excluded and the best match can be determined.

The matching methodology begins by assigning probabilistic scores for each potential match. The score is developed by summing a set of weights that are assigned to each of the identifying data items used in the NHIS-NDI record match. The weights reflect the degree of agreement between the information on the NHIS submission record and the NDI death record. NCHS developed the weights, known as binit weights, based upon the frequency of occurrence of the 12 data items in the NDI files for years 1979 to 2000, which represents about 49 million persons. The weights correspond to $[\text{Log}_2 (1/p_i)]$, that is base 2 logarithm of the inverse of the probability of occurrence of the value of the identifying data item on the submission record. Examples of how weights were created for specific identifying data items are provided below:

- Social Security number – each digit in each position of the SSN (1 to 9) has a corresponding weight, with the total SSN weight being the sum of the weights for each of the nine digits. For a record to be assigned the total SSN weight, there needs to be agreement on at least 8 digits. If seven digits agree, then 7/9 of the total weight is assigned. If fewer than seven digits agree then the total SSN weight becomes negative.
- Name - common values, such as "John", that have a higher probability of occurrence have lower weights (10.7) than uncommon name such as Jonas (19.7). First name weights are stratified by both sex and year of birth since first names are sex specific and the popularity of first names varies over time. Weights for first and last names are limited to a finite set of values and any name not appearing in the set (meaning it is less common) receives the maximum value of the weight.

Weights are either positive or negative. If there is agreement between the NHIS record and the NDI record for a particular identifying data item, the weight is positive. If there is no agreement, the weight is negative. Some items, such as year of birth, allow a tolerance (+/- 3 years) and are still considered to agree. With the exception of middle initial, data items that are missing on the NHIS submission record, the NDI record, or both are assigned a weight of zero. A blank middle initial is considered a valid value and receives the appropriate weight. For information on the values for the weights for each of the identifying data items, please refer to the detailed description of the SCORE variable found on page 3 in detailed notes for selected variables.

Once weights have been created for each individual data item, they are summed to create a score for each potential match.

$$\textbf{\textit{Score}} = \{\sum W_{SSN1} + \ldots + W_{SSN9}{}^{4}\} + W_{firstname\ x\ sex\ x\ birthyear} + W_{middleinitial\ x\ sex} + W_{lastname} + W_{race} + W_{sex} + W_{maritalstatus\ x\ sex\ x\ age} + W_{birthdate} + W_{birthmonth} + W_{birthyear} + W_{stateofbirth} + W_{stateof\ residence}$$

[4] For a record to be assigned the maximum weight for SSN, there needs to be agreement on at least 8 digits. If seven digits agree, then 7/9 of the total weight is assigned. If fewer than seven digits agree then the total SSN weight becomes negative.

After scoring the potential matches, each is categorized into one of five mutually exclusive classes. Whereas weighting and scoring take into account the probability that the NHIS record and the NDI record share a particular value for the identifying items, the classes take into account which identifying items agree. The class categories reflect the fact that some of the 12 NDI identifying items are more important for determining true matches than others. For example, since SSN is a key identifier in the matching process, each NHIS-NDI record match is initially categorized into whether SSN is present and agrees (Class 1 or 2), present but disagrees (Class 5) or missing (Class 3 or 4). Additionally, non-changing identifying information is more important than information that can change over time. For example, many women assume their spouse's name at marriage, a common example of legitimate change over time. However, birth surname does not change and so becomes an important matching variable for women. State of residence and marital status may change between the NHIS interview date and the date of death and so become less important matching variables.

The final five Classes used by NCHS for the 2004 Linked Mortality files are described below[5].

Class 1: Agrees on at least 8 (of 9) digits of SSN, first name (including NYSIIS match), middle initial (including blank), last name (including NYSIIS match), birth year (+/- 3 years), birth month, sex, and state of birth.

Class 2: Agrees on at least 7 digits (of 9) digits of SSN and at least 5 more of the following items: first name (including NYSIIS match), middle initial (including blank), last name (including NYSIIS match), birth year (+/- 3 years), birth month, sex, and state of birth.

Class 3: There are two types of Class 3 matches:

Type A: SSN is unknown, but last name matches (including NYSIIS match) and at least 7 of the following items agree: first name (including NYSIIS match), middle initial (including blank), last name (including NYSIIS match), birth year (+/- 3 years), birth month, sex, and state of birth.

Type B: Records in this category were initially put in Class 5 but switched to Class 3[6]. SSN is known but 3 or more digits do not agree, but at least 8 of the following items agree: first name (including NYSIIS match), middle initial (including blank), last name (including NYSIIS match), birth year (+/- 3 years), birth month, sex, and state of birth, with last name and sex having to be in agreement.

[5] All total scores were adjusted to reflect the final class code for the potential matches. For example, any record that was switched from Class 5 to Class 3 had its score adjusted to reflect that SSN is missing, with the value of 0 assigned to SSN.

[6] Potential matches in Class 5 are moved to Class 3 if there is the possibility that SSN was either recorded incorrectly or that the spouse's SSN was recorded instead of the subject's SSN.

Class 4: SSN is unknown on either the NHIS submission record or the NDI record and fewer than 8 of the items listed in Class 3 match.

Class 5: SSN is present but fewer than 7 (of 9) digits on SSN agree or at least 7 digits on SSN agree but fewer than 5 of the following items agree: first name (including NYSIIS match), middle initial (including blank), last name (including NYSIIS match), birth year (+/- 3 years), birth month, sex, and state of birth or at least 7 digits of SSN and last name agree, but sex and first name to not agree (indicating that a deceased spouse's SSN is recorded).

4: Selecting matches and assigning vital status

As already described in Section 2, each eligible NHIS participant may have multiple submission records and each submission record may return one or more matches to a NDI record. The 2004 NHIS Linked Mortality files do NOT include all of the potential matching NDI records. Rather, for those NHIS participants with a potential match to the NDI, NCHS employed a strategy to provide the single best NDI match record for inclusion on the linked NHIS mortality file.

First, NHIS-NDI potential match records that had a date of death prior to the date of interview, a score of zero or less, or final categorization of Class 5 were considered false matches and eliminated from the pool of potential matches. Next, among the remaining pool of potential matches, match records that referred to the same death certificate (duplicates) were eliminated. This process eliminated about 85% to 90% of the pool of potential matches. However, many participants still had more than one NDI record as a potential match. The remaining potential matches for each eligible NHIS participant were ranked first on class (from 1 to 4) and then within class by highest score. The NDI match with the highest score within the best class was selected as the one match for inclusion on the mortality file. In the event that there is a tie between NDI record matches for a particular NHIS record, the tiebreaker is based on the importance of matching items[7]. Once NCHS selected the single best record match, NCHS determined whether the match was true or false.

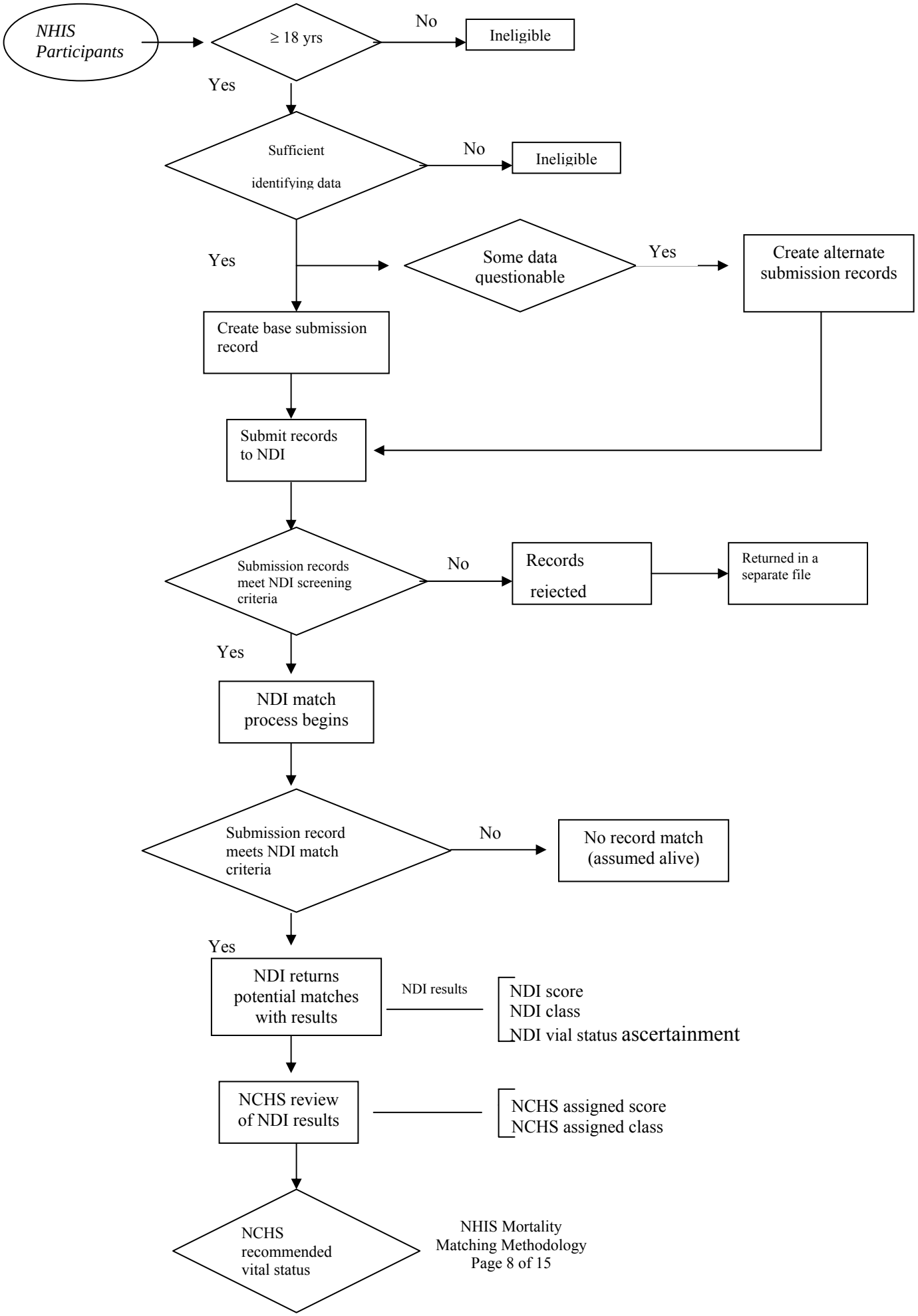
A true match reflects *both* the correct vital status of the survey participant and a match to the correct death certificate data. All Class 1 match records were considered true matches. For match records with Classes 2, 3, and 4, NCHS determined whether the match was true or false using cut-off scores developed from the NHANES I Epidemiologic Follow-Up Study (NHEFS) calibration sample, which has verified mortality outcomes for its sample. Within each class, matches with a score *greater than or equal* to the cut-off score were considered true matches, while records with a score less than the cut-off were considered false matches. *The cut-off scores for Classes 2, 3, and 4 were 47, 45, and 40, respectively.* In general, the process was to select the cut-off scores within Classes 2, 3, and 4 that simultaneously maximized the proportion of people correctly classified and minimized the number of people incorrectly classified, with particular attention given to minimizing the number of false positives. Users should refer to Appendix B for a description of the results of the calibration study.

[7] The order is: number of digits of SSN; sex; last name; first name; state of birth; year of birth; month of birth; day of birth. If all of these are the same, then a random number is used.

Final Notice to Users

Not every NHIS participant with an NDI record is considered deceased. Some NHIS participants with a NDI record will have a vital status of 1 (assumed deceased) and others will have a status of 0 (assumed alive). Eligible NHIS participants with no NDI record match are assumed to be alive. Ineligible NHIS respondents should be excluded from mortality analyses. NCHS has provided the SCORE and CLASS for the best NDI record match, regardless of the final assigned vital status, to provide the user with the opportunity to alter the criteria for determining final match status. The user can take either a more or less conservative approach to vital status ascertainment by setting a different cut-off score within each class and/or determining which classes contain true matches. Please refer to Appendix C for an example of the implications of using alternate cut-off scores on vital status ascertainment.

Figure 1: NHIS-NDI Matching Process



Appendix A

Creating Alternate Submission Records

The primary purpose of using alternate submission records is to increase the chances of returning a correct death record for those NHIS participants who are, in fact, deceased. The NDI allows multiple alternate submission records for each survey person. Rules for creating alternate NDI submission records were based upon a calibration study using the NHANES I Epidemiologic Follow-up Study (NHEFS). The NHEFS calibration study has a sample of 12,699 people whose vital status is known for a definite time period beginning January 1979 through either the date of death for decedents or a final interview date for non-decedents. NCHS created base submission records for this sample and submitted them to the NDI record retrieval process. For those known to be deceased but who did not return an NDI record match, NCHS compared the identifying information on the submission record to the information on the death certificate. The process revealed the most common reasons a NDI record was not returned.

Name inaccuracies are the most common type of mismatch error encountered when matching to the NDI system. Since death certificates are official records, they will list the full proper name of the decedent. However, survey respondents may provide nicknames or middle names as their first names. To account for nicknames being listed as the first name, NCHS used a nickname to proper name conversion process that created alternate submission records with the most popular formal name associated with that nickname. For example, if a NHIS record listed the respondent name as Beth, two submission records were created. The base submission record included Beth as first name and the alternate submission record included Elizabeth as the first name.

Multipart first or last names also increase the chances of a NHIS and NDI record not matching. Such differences in name reporting are particularly common for the U.S. Hispanic population. For example, mother's and/or father's surname may both be reported as two last names in a particular order during the survey contact but may be reversed on the death record. To take into account potential recording discrepancies caused by multi-part names, alternate records were created using all of the components of multi-part names both separately and together. Only names with either a space or hyphen are treated as multipart names.

Middle initial plays an important role in NDI matching. Since the NDI allows a blank as a valid value for middle initial, an alternate record is created by dropping the middle initial from any base submission record where it is non-blank.[8] A comparison of known correct matches where middle initial is missing on either the survey data record or the correct matching NDI record found that the overlap is less than 50% of those records. Therefore, for the NDI selection process, NCHS believes converting non-blank middle initials to blank to be a useful alternate submission strategy.

[8] Preliminary research performed at NCHS has found that many survey data files include a blank middle initial about 25% of the time, making blank the single most commonly reported middle initial.

In summary, for the NHIS-NDI linkage, the following rules were used for generating alternate submission records:

1. Use proper name in place of nickname for first name
2. Multipart first and last names are submitted as is, and alternately each part of the name is submitted as the first or last name
3. Switch first name and middle name
4. Blank out middle name
5. Add alternate surnames when evidence of legal name change is available
6. When Medicare number is available, substitute Medicare number for Social Security Number (SSN) (note: some subjects have a Medicare number but no SSN)
7. Use alternate birth date or SSN data, if collected
8. If month of birth is missing, submit twelve records, one with each month

The rules for alternate submission record creation are multiplicative in nature. For example, a participant may have both an imputed month of birth (12 separate records) and two-part first name (3 separate records) resulting in 36 NDI submission records.

Appendix B

NHANES I Epidemiologic Follow-up Calibration Sample

Since the NDI record selection and match processes do not have an independent means of assessing whether a NHIS-NDI match is true or false, NCHS undertook a calibration study to determine the adequacy of the probabilistic approach utilized to match NHIS participants to NDI records. Such a study is necessary in order to assess the number of false negatives and false positives.

With regard to false negatives, there are several ways that a death to a NHIS participant could be missed. Some of these ways are due to the universe of deaths in the NDI, some to the NDI selection process and some to the ranking, scoring and classification of matches employed by NCHS in the NHIS-NDI linkage (see sections 3 and 4 of the main document). Specifically, there are five ways a death could be missed in the NHIS mortality files:

- Deaths outside the United States are not included in the NDI;
- A small number of deaths (occurring in the U.S.) are not part of the NDI database;
- Deaths not retrieved in the NDI selection process;
- True deaths that are not the top ranked death record by NCHS and are dropped from the pool of potential matches;
- True NDI records are selected but the NCHS score for that match was below the threshold for determining a match a true match.

False positives often arise by finding a match for a relative or someone with a common name. However, also there are a small number of false positives that arise when true decedents are matched to the wrong NDI record. Although these individuals are assigned the correct vital status, since it is the wrong death record, the date and cause of death are unlikely to be correct.

The calibration study used the NHANES I Epidemiologic Follow-up survey (also known as NHEFS), which was conducted from 1971-1992. NHEFS provides a unique opportunity to assess the quality of the NHIS-NDI matching process because it is a longitudinal study with a high participation rate and highly complete and verified identification data. In the NHEFS sample, there are 12,699 people for whom active follow-up was conducted so that their vital status is known beginning January 1979[9] through either the date of death or a final interview date (for non-decedents). Among this sample, four deaths occurred outside the United States, leaving 3,454 deaths that were available to be included in the NDI database and for which a match to a NHEFS participant was possible. NCHS applied the same approach for creating submission records, selecting NDI records, and ranking, scoring, and classifying matches to the NHEFS sample as for the NHIS-NDI linkage to determine how many of the 3,454 deaths could be found.

Figure 2 depicts the selection process and match status determination of the NHEFS sample. Among the 3,454 NHEFS decedents, 3,380 had a NDI record selected as a potential match and 74 did not. Among the NDI potential matches for the NHEFS decedents, 3,375 had the *correct*

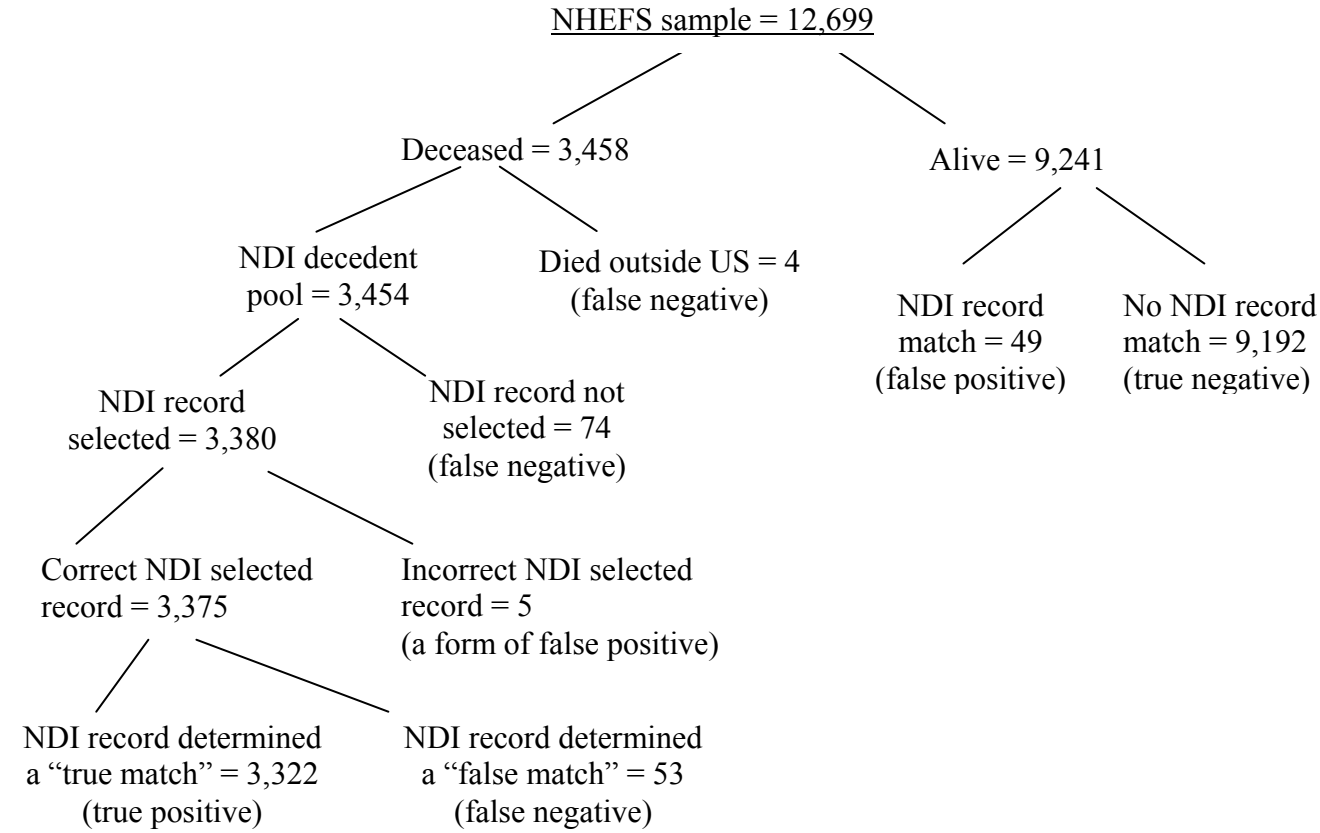
[9] The NDI was established in 1979. Persons in the NHEFS sample who died before 1979 were not considered in this study.

NDI record selected. Using the cut-off scores for Classes 2, 3, and 4 as described in section 4 of the documentation, resulted in 3,322 being considered true matches and correctly assigned as deceased, whereas 53 were considered false matches and incorrectly assigned a vital status as alive. Additionally, there were 79 NHEFS decedents who did not have a true match to a NDI record - 5 were decedents who were assigned as dead, but because their NDI record match is to the wrong person, the date and cause of death will not be correct (a form of false positive) and 74 were decedents who did not return a NDI record and were incorrectly assigned a vital status of alive. Among NHEFS non-decedents, 49 returned a NDI record that was selected as a true match and were incorrectly assigned a vital status of deceased. Table 1 shows the cut-off scores for Classes 2, 3, and 4 employed to determine the match status of NDI potential matches to NHEFS records and the proportion correctly classified. Based upon the matching methodology described for the NHIS Linked Mortality files, 96.1% of NHEFS decedents were correctly classified as deceased and matched to the correct death certificate, 99.4% of non-decedents were correctly classified as alive, with an overall 98.5% of NHEFS respondents correctly classified.

Table 1:Cut-off scores and proportion of NHEFS subjects correctly classified.

Within Class	Cut-off Score	Correctly classified overall (%)	Correctly classified as dead (%)	Correctly classified as alive (%)
2	≥ 47	98.0	98.5	40.0
3	≥ 45	89.7	94.7	67.5
4	≥ 40	98.6	60.5	99.4

Figure 2.


NHEFS sample = 12,699
Deceased = 3,458
Alive = 9,241
NDI decedent pool = 3,454
Died outside US = 4 (false negative)
NDI record match = 49 (false positive)
No NDI record match = 9,192 (true negative)
NDI record selected = 3,380
NDI record not selected = 74 (false negative)
Correct NDI selected record = 3,375
Incorrect NDI selected record = 5 (a form of false positive)
NDI record determined a "true match" = 3,322 (true positive)
NDI record determined a "false match" = 53 (false negative)

Appendix C

Altering the criteria to assign vital status

The 2004 Linked Mortality File includes the NCHS recommended vital status ascertainment (MORSTAT) for each eligible NHIS participant. For NHIS participants with a NDI record match, the file also includes the NCHS class and score for that record from which the determination of vital status was made. The CLASS and SCORE variables are included on the file so that users can alter the criteria for determining vital status and conduct their own sensitivity analyses. The choice of cut-off scores involves decisions regarding sensitivity and specificity. Alternative criteria for determining vital status must balance the trade-off of false positives versus false negatives. Below are two examples of studies evaluating different criteria to ascertain vital status for NHIS-NDI match records.

Using the 1986-1990 NHIS linked to the NDI with mortality follow-up through 1991, Liao et al. (1998) evaluated mortality rates using three different criteria to identify deaths. Criteria 1 was the most conservative, requiring an exact match on SSN. Only NHIS participants with a NDI record with a Class 1 or 2 match were considered true matches and assumed deceased; Criteria 2 was the NCHS recommended ascertainment of vital status using NCHS's cut-off scores[10]; and Criteria 3 was the least stringent with all of Class 1, 2, and 3 matches plus Class 4 matches with scores higher than the recommended cut-off considered true matches. Mortality estimates were lowest based upon criterion 1 and highest with criterion 3. Furthermore, the use of different criteria to determine vital status had differential effect upon mortality rates for sex and race/ethnic groups.

Using the 2004 NHIS Linked Mortality files for the NHIS years 1988-1994, NCHS conducted its own evaluation of alternative criteria to assign vital status and its impact on mortality rates. Four criteria were evaluated to determine whether a match was considered true or false. For all four criteria, Class 1 match records were considered true matches (No. assumed deceased = 36,345). The four criteria differed in the established cut-off scores for determining which Class 2, 3, or 4 matches were true matches.

[10] Users should note that since this analysis is based upon a previous NHIS-NDI record linkage, the NCHS recommended classifications and cut-off scores are different from the recommended classifications and cut-off scores in 2004 NHIS Linked Mortality files.

Criteria	Match Record Class	Match Record Score	No. Assumed Dead
Criterion 1: NCHS recommendation[11]	2 3 4	≥ 47 ≥ 45 ≥ 40	10,273 11,855 2,548
Criterion 2	2 3 4	All ≥ 45 None	10,734 11,855 --------
Criterion 3 (4 points above NCHS recommended cut-off scores)	2 3 4	≥ 51 ≥ 49 ≥ 44	10,038 10,817 1,291
Criterion 4 (4 points below NCHS recommended cut-off scores)	2 3 4	≥ 43 ≥ 41 ≥ 36	10,415 12,595 4,787

Criterion 3 produced the most conservative results with 58,934 deaths overall and criterion 4 the least conservative with 64,142 deaths. The NCHS recommended cut-off scores produced 61,021 deaths overall. Not surprisingly, altering the matching criteria differentially affected the mortality rates by race/ethnicity, sex, and age, with Hispanics being the most affected.

Inferences from studies that use the NHIS Linked mortality files could be affected by the matching criteria chosen and the ascertainment of vital status. Researchers interested in examining the robustness of their findings can perform sensitivity analyses by altering the criteria for matching. This may be particularly important for studies examining mortality patterns for specific race/ethnic groups.

[11] The values for MORSTAT on the 2004 NHIS Linked Mortality files are based upon this criterion.